RECORDS FROM A VIRGIN STAND
OF PONDEROSA PINE
FORT VALLEY EXPERIMENTAL FOREST

Data Assembled by G. A. Pearson

1944

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EXPERIMENT STATION

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Virgin Stands Are Not Static

It is generally assumed that virgin stands are more or less static, or that growth is offset by mortality. That must be true of fully stocked stands as they approach maturity, otherwise the volume per acre would increase indefinitely. If, on the other hand, the stand is not fully stocked and especially if it contains young as well as old age classes, growth may exceed mortality until such time as an equilibrium is reached. Since ponderosa pine forests are seldom fully stocked or even-aged, one may expect their volume to increase under protection. Such has been the case in a virgin stand of 12,500 board feet per acre on sample plot S6 in the Fort Valley Experimental Forest, measured periodically since 1915. Since the Fort Valley stand is rather heavier than the average for the Coconino Plateau, it is reasonable to regard its record as conservative and somewhat typical of stands in Arizona and New Mexico, and at least suggestive of relationships in other regions.

That immature age classes, including pole and sapling stages, may be well represented in heavy old-growth stands in the Southwest is demonstrated by the 80-acre sample plot S9 in the same section as S6. Sample plot S9 bore a stand of 18,500 board feet per acre before logging, and yet, as illustrated in figure 1, the yellow pine class occupied only 22.8 percent of the total area; blackjack and poles occupied 13.6/ percent and reproduction, mainly in the sapling stage, about 50 percent. In this chart the space occupied by blackjack and yellow pine 12 inches and over d.b.h. was assumed to extend out to a rather well-defined line marked by reproduction of normal development. Although this line was always far outside of the crown projections, it marks a zone within which pine seedlings do not thrive.

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LEGEND

— SAPLINGS, 1 TO 25 YEARS

— POLES, 25 TO 80 YEARS

— BLACKJACK, 80 TO 200 YEARS

— YELLOW PINE, OVER 200 YEARS

Area by Groups Before Logging

Yellow Pine	22.8%
Blackjack	10.4%
Poles	3.2%
Total	36.4%

All but 5 to 10 percent of the remaining space is occupied by reproduction

Figure 1.— AREA DISTRIBUTION OF AGE GROUPS

VIRGIN PONDEROSA PINE

SAMPLE PLOT S9, 80 ACRES

FORT VALLEY EXPERIMENTAL FOREST

100 200 300 400 500

SCALE — FEET

Parallel Records in a Virgin and a Cut-Over Stand

In the following series of tables, the performance of the virgin stand is judged by comparing it with an adjoining cut-over stand. Sample plot S6, representing the virgin stand, was established in 1915. In 1924 a comparable area of 160 acres was logged under group selection, and a year later it became sample plot S7. At the same time S6 was enlarged from 120 to 160 acres. The parallel records thus began in 1925. Records on 120 acres of the virgin stand, however, extend back to 1915, covering a period of 25 years.

Table 1 shows the stand composition and volume on the two areas in 1925 and 1940. Although S7 was not measured before logging, reconstruction from timber sale records indicates that the two areas had nearly equal volumes. It is evident, however, from the tables that S7 had more trees in the lower diameter classes, beginning at about 18 inches d.b.h. and extending down through the pole stage. By 1940 this relation had become still more accentuated, indicating that trees in the lower classes had prospered following the removal of larger neighbors.

TAble 1.-- Number of trees and volume per acre in virgin and cut-over stands, 1925 and 1940.

Virgin Stand, Sample Plot S6, 160 Acres

D.b.h. class	1925		1940	
	Trees	Volume	Trees	Volume
Inches	No.	Ft.b.m.	No.	Ft.b.m.
9-11	2.33		3.83	
12-14	2.36	143	2.85	171
15-17	2.83	375	2.51	330
18-20	3.31	833	3.28	838
21-23	3.35	1,435	3.45	1,496
24-26	2.83	2,097	2.93	2,190
27-29	2.02	2,132	2.24	2,347
30-32	1.46	2,000	1.57	2,145
33-35	0.72	1,260	0.77	1,360
36-38	0.34	766	0.37	805
39-41	0.19	505	0.19	523
42-44	0.06	181	0.08	246
45-47	0.01	24	0.01	24
48-50	0.01	27	0.01	29
Total	21.82	11,778	24.09	12,504

Cut-over Stand, Sample Plot S7, 160 acres

D.b.h. class	1925		1940	
	Trees	Volume	Trees	Volume
Inches	No.	Ft.b.m.	No.	Ft.b.m.
9-11	5.93		11.93	
12-14	4.18	219	5.97	300
15-17	3.73	472	4.17	542
18-20	2.61	653	3.21	780
21-23	1.76	733	2.41	1,001
24-26	0.86	558	1.53	984
27-29	0.46	425	0.65	612
30-32	0.16	196	0.31	404
33-35	0.04	62	0.08	124
36-38	0.02	67	0.02	38
39-41			0.02	47
Total	19.75	3,385	30.30	4,832

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Figure 2.— Virgin stand showing five age classes.

Blackjack and Yellow Pine

In table 2 the stand above the 11-inch diameter class is separated into two broad age classes: blackjack or immature (including intermediate class) and yellow pine or mature and overmature.

The effect of cutting is especially pronounced in the yellow pine class of S7 where the volume of yellow pine was reduced to less than 1,000 board feet per acre. Examination of this area reveals that cutting practice departed from the usual group selection in both yellow pine and blackjack groups. The presence of good advance reproduction lowered the seed-tree requirements. Yellow pine groups were cut almost clean, but the few remaining trees were relatively large. Blackjack groups were opened up by taking out subordinates of merchantable size, in direct contrast to the favoring of subordinates in the Improvement Selection method of recent development.

Table 2.-- A comparison of the two broad age classes, blackjack and yellow pine, in a virgin and a cut-over stand, 1925 records.

Virgin Stand (Sample Plot S6) - 160 Acres

D.b.h. class	Number of trees per acre			Volume board feet per acre		
	Blackjack	Yellow pine	Total	Blackjack	Yellow pine	Total
12-20	6.49	2.02	8.51	966	386	1,352
21-30	2.67	6.09	8.76	1,472	4,886	6,358
31+	0.03	2.19	2.22	40	4,028	4,068
Total	9.19	10.30	19.49	2,478	9,300	11,778

Cut-Over Stand (Sample Plot S7) - 160 Acres

D.b.h. class	Number of trees per acre			Volume board feet per acre		
	Blackjack	Yellow pine	Total	Blackjack	Yellow pine	Total
12-20	10.05	0.46	10.51	1,263	81	1,344
21-30	2.21	0.96	3.17	1,180	648	1,828
31+	0.01	0.12	0.13	16	197	213
Total	12.27	1.54	13.81	2,459	926	3,385

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Figure 3.— Fully stocked virgin stand in which trees of saw-timber size occupy a relatively small proportion of the soil area. Blackjacks in right background are growing vigorously, but the group of yellow pines at the left and those in the far distance are barely keeping pace with mortality.

Diameter Growth

Table 3 shows the growth rate as well as number of trees by diameter classes on the two areas. Below the 12-inch class diameter growth in the virgin stand compares favorably with that in the cut-over stand, but the cut-over stand has many more trees per acre. Beginning with the 12-inch class diameter growth forges ahead in the cut-over stand and this lead is retained throughout the series.

In the 17-inch class and upward the effect of cutting exerts itself in lowering the number of trees in the cut-over stand.

Notwithstanding a marked superiority of the cut-over stand, growth in the virgin stand was by no means negligible. Even in diameter classes above 30 inches, growth continued at a rate well above a half inch per decade, which in trees of this size means considerable volume increment. Although corresponding diameter classes in the cut-over stand grew from two to three times as fast, the fact remains that the large trees in the virgin stand were going ahead. The reason is that most of them are partially isolated. Now that reproduction has come in, young trees will claim an ever increasing share of the meager moisture supply which the veterans were able to monopolize as long as fire and grazing prevented regeneration. It is to be expected that another 20 years will witness a marked decline in the growth of large trees; even the cut-over area will probably experience this change because, although the large trees were well isolated by cutting, saplings have encroached on their root zones.

Table 3.-- Diameter growth of ponderosa pine in a virgin stand compared with a cut-over stand. Sample plots S6 and S7, Fort Valley Experimental Forest, 1925 to 1935. Area of each plot, 160 acres.

D.b.h. class	Trees in class, 1925		Diameter growth 1/ 1925-1935	
	Virgin	Cut-over 1935	Virgin	Cut-over
	No.	No.	In.	In.
4-5	605	2,396	1.91	1.74
6-8	635	2,109	1.69	1.78
9-11	367	996	1.66	1.65
12-14	376	681	1.01	1.58
15-17	447	599	0.99	1.58
18-20	522	417	0.92	1.62
21-23	525	273	0.84	1.42
24-26	443	135	0.76	1.35
27-29	313	67	0.62	1.20
30-32	220	26	0.54	1.25
33-35	108	6	0.52	1.19
36-38	51	4	0.41	1.54
39-41	30		0.40	
42-44	8		0.37	
45-47	1		-	
48	1		1.00	

1/Not curved.

Periodic Gross Increment and Mortality

Gross increment, according to table 4, is so nearly equal in the two stands that the minor differences may be disregarded. Since the per-acre volume of the virgin stand is practically three times as great as that of the cut-over stand, it becomes evident that a large portion of the virgin stand is essentially nonproductive.

Mortality, as shown in table 5, further decreases the efficiency of the virgin stand as a growing stock.

Mortality fluctuates greatly in the virgin stand when taken by 5-year periods. This is best shown by the 25-year record in table 9. Variable weather conditions including wind, lightning, and drought play their part; but back of this is the fact that the stand contains a high proportion of large and highly vulnerable trees. Cutting effectually reduced the mortality on S7. Even the crest of 1935-1940, when the virgin stand lost 102 board feet per acre annually, is scarcely noticeable in the cut-over stand.

Table 4.- Periodic annual gross increment per acre and in percent of volume 1/ in virgin and cut-over stands.

Forest	1925 to 1930		1930 to 1935		1935 to 1940	
	Ft.b.m.	Percent	Ft.b.m.	Percent	Ft.b.m.	Percent
Virgin	121	1.03	111	0.91	105	0.84
Cut-over	108	3.19	109	2.81	110	2.52

1/Percent of total volume at the beginning of each 5-year period.

Table 5.--- Periodic annual mortality per acre and in percent of volume 1/ in virgin and cut-over stands.

Forest	1925 to 1930		1930 to 1935		1935 to 1940	
	Ft.b.m.	Percent	Ft.b.m.	Percent	Ft.b.m.	Percent
Virgin	45	0.38	44	0.36	102	0.82
Cut-over	10	0.29	13	0.33	14	0.32

1/Percent of total volume at the beginning of each 5-year period.

Mortality by Broad Diameter Classes and Age Classes

Table 6 gives in percent of original stand the loss in number of trees and volume per acre by broad diameter groups and separately for blackjack and yellow pine, over a period of 15 years.

In both virgin and cut-over stands the mortality rate is much higher for yellow pine than for blackjack, and in general mortality rises with diameter. The reasons, for this increase in diameter, are in large measure the same in both instances, i.e., the largest trees are yellow pines. Aside from the question of relative susceptibility, however, large trees entail the largest volume loss because of their high volume content.

In all diameter classes the loss in actual volume or number of trees is much higher in the virgin than in the cut-over stand; on a percentage basis, however, the relation is sometimes reversed, due to the lower volume base in the cut-over stand.

Table 6.- Mortality during a 15-year period in a virgin and a cut-over ponderosa pine stand, blackjack and yellow pine separate, 1925 to 1940.

Virgin stand, 160 acres

1925 d.b.h. class	Number of trees lost, per acre and percent[1]						Volume lost, board feet, per acre and percent[1]							
	Blackjack		Yellow pine		Total		Blackjack		Yellow pine		Blackjack and yellow pine Total		Annual	
Inches	No.	Pct.	No.	Pct.	No.	Pct.	Ft.	Pct.	Ft.	Pct.	Ft.	Pct.	Ft.	Pct.
12-20	0.09	1.39	0.12	5.94	0.21	2.47	14	1.46	23	5.96	37	2.74	2.5	0.18
21-30	0.04	1.50	0.42	6.90	0.46	5.25	19	1.29	346	7.08	365	5.74	24.3	0.38
31+			0.28	12.78	0.28	12.61			505	12.54	505	12.41	33.7	0.83
12+	0.13	1.41	0.82	7.96	0.95	4.87	33	1.33	874	9.40	907	7.70	60.5	0.51

1/Percent of 1925 stand.

Cut-over stand, 160 acres

1925 d.b.h. class	Number of trees lost, per acre and percent[1]						Volume lost, board feet, per acre and percent[1]							
	Blackjack		Yellow pine		Total		Blackjack		Yellow pine		Blackjack and yellow pine Total		Annual	
Inches	No.	Pct.	No.	Pct.	No.	Pct.	Ft.	Pct.	Ft.	Pct.	Ft.	Pct.	Ft.	Pct.
12-20	0.15	1.34	0.03	6.52	0.18	1.71	22	1.74	5	6.17	27	2.01	1.8	0.14
21-30	0.10	4.52	0.11	11.46	0.21	6.62	44	3.73	90	13.89	134	7.33	8.9	0.48
31+	0.00	0.00	0.01	8.33	0.01	7.69	0	0.00	14	7.11	14	6.57	1.0	0.44
12+	0.25	2.04	0.15	9.74	0.40	2.90	66	2.68	109	11.77	175	5.17	11.7	0.35

1/Percent of 1925 stand.

Causes of Mortality

The main causes of mortality and their relative importance are listed in table 7. They are lightning, wind, bark beetles, and mistletoe.

Lightning ranked first on both areas. Annual lightning losses per acre were 25.6 board feet in the virgin and 6.0 in the cut-over stand. In view of the fact that only one-third of the trees struck by lightning died (__), though suffering considerable deterioration and loss of vigor, mortality figures fall far short of measuring the total damage by lightning.

Bark beetle mortality ranked close to lightning in the virgin stand but was relatively low in the cut-over stand, indicating that logging removed the most susceptible trees. The lowering of competition by cutting, and consequent increase in moisture availability, is thought to be an important contributing factor. The annual loss per acre due to bark beetles was 16.5 board feet in the virgin stand and only 1.3 in the cut-over.

Wind was thought, prior to this compilation, to be the major agent of mortality in the virgin stand; but it is responsible for less than half the volume loss of lightning and only two-thirds that of bark beetles. The annual per acre loss due to wind was 11 board feet in the virgin stand and 2.7 in the cut-over.

Mistletoe, usually about on a par with lightning and wind in cut-over stands, was low on both of these areas because relatively few trees are infected.

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Figure 4.— Mortality among large trees of the class here shown may register a large paper loss but they are all of low grade and their removal is a direct benefit to the young stand.

Table 7.- Causes of Mortality in a virgin and a cut-over stand, 1925-1940.

A. Virgin stand, Sample Plot S6, 160 acres

D.b.h. class	Lightning		Wind		Bark beetles		Mistletoe		Unclassified		Total	
	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.
Inches	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
12-20	0.4	0.4	0.5	0.6	0.8	0.8	0.3	0.3	0.5	0.6	2.5	2.7
21-30	1.4	1.9	1.4	1.3	2.0	2.0	0.1	0.1	0.3	0.4	5.2	5.7
31+	6.3	6.4	1.8	1.7	2.7	2.7	0.4	0.3	1.4	1.3	12.6	12.4
12+	1.5	3.3	1.0	1.4	1.6	2.1	0.3	0.2	0.5	0.7	4.9	7.7
Percent of total mortality[1]	30.6	42.8	20.4	18.2	32.7	27.3	6.1	2.6	10.2	9.1	100.0	100.0

1/ Percent of 1925 stand.

B. Cut-over stand, Sample Plot S7, 160 acres

D.b.h. class	Lightning		Wind		Bark beetles		Mistletoe		Unclassified		Total	
	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.	No. trees	Volume b.m.
Inches	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
12-20	0.5	0.8	0.2	0.2	0.1	0.2	0.4	0.4	0.5	0.4	1.7	2.0
21-30	4.1	4.4	1.3	1.2	0.6	0.9			0.6	0.8	6.6	7.3
31+			7.7	6.6							7.7	6.6
12+	1.3	2.6	0.5	1.2	0.3	0.6	0.3	0.2	0.5	0.6	2.9	5.2
Percent of total mortality[1]	44.8	50.0	17.2	23.2	10.4	11.5	10.4	3.8	17.2	11.5	100.0	100.0

1/Percent of 1925 stand.

Periodic Net Increment and Mean Increment

Periodic net increment in the two stands is shown in table 8. As may be expected from the mortality records in table 5, the cut-over plot leads by a wide margin. Comparing the 15-year means, the net increment of the cut-over stand is twice that of the virgin stand, and on a percentage basis the ratio is 7 to 1.

Notwithstanding the foregoing contrasts, the virgin stand registered a positive increment in all three periods, and the 15-year mean of 48 board feet is by no means insignificant. The 25-year record in table 9 gives essentially the same value, or 47 board feet per acre annually. The fact that mortality was extremely high in two of the five periods tends to strengthen the conclusion that, despite mortality, the virgin stands of the Southwest are gradually increasing their volume.

Table 8.- Periodic annual net increment in volume per acre and in percent 1/ in virgin and cut-over stands. 1925 to 1940.

Forest	1925 to 1930		1930 to 1935		1935 to 1940		Mean 1925 to 1940	
	Ft.b.m.	Pct.	Ft.b.m.	Pct.	Ft.b.m.	Pct.	Ft.b.m.	Pct.
Virgin	76	0.65	67	0.55	3	0.02	48	0.41
Cut-over	98	2.90	96	2.48	96	2.20	96	2.84

1/Percent of total volume at beginning of period.

Table 9.- Increment and mortality by 5-year periods in a virgin stand of ponderosa pine, 1915 to 1940.

	Annual increment or loss in board feet per acre				
	1915-20	1920-25	1925-30	1930-35	1935-40
Gross increment	124	139	116	106	102
Mortality	41	107	50	40	112
Net increment	83	32	66	66	-10

	20 yrs.	25 yrs.
Mean net increment in board feet per acre	62	47
Mean net increment percent	0.57	0.43

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Figure 5.—Salvage in dense stands should do more than remove dying trees; it should anticipate mortality by taking out large, high-risk trees and by relieving congestion in dense groups.

Management Should Begin Before Logging

The behavior of virgin stands is of great importance in regions where large areas are likely to remain uncut 20 years or more. Such is the case in the Southwest. An average annual increment of 40 board feet per acre on a million acres for 20 years would contribute a total of 800 million board feet. Areas bearing less than 15,000 board feet per acre of old timber but well stocked with poles and saplings in large open spaces should exceed the estimate of 40 board feet. Exceptions will occur locally where there is a deficiency of blackjacks, but the decline on such areas will be temporary. It is not over-optimistic to say that under management most uncut stands in Region 3 can be made to increase their volume at a rate of 50 board feet annually over a period of 40 years, where cutting is deferred that long.

How management short of logging operations can increase production in virgin stands is a subject worthy of thought. Much concern has been expressed about loss through mortality and deterioration. Light cuttings designed to salvage the most susceptible trees have been suggested; in fact, one area of 80 acres in the Fort Valley Experimental Forest has been logged on that plan. The trouble is that highly susceptible trees usually constitute more than half of the total volume. Large trees, no matter how healthy in appearance, are a mark for wind and lightning. Mistletoe-infected trees are almost sure to succumb sooner or later. In crowded groups some trees are likely to die or decline during drought periods, either as a direct effect of competition for moisture or indirectly by increasing susceptibility

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Figure 6.— Sooner or later all virgin stands acquire a sky line such as this. What is really important is the young generation.

to bark beetles. Merely salvaging defective or distinctly declining trees will accomplish little unless repeated every 5 to 10 years because their usable volume is low and their ranks are continually being replenished. Actually, the loss of such trees is not great because their demise usually makes way for younger trees on the immediate site, assuming that protection has permitted advance reproduction. It is far more important to salvage the younger generation—small blackjacks, poles, saplings, and seedlings. Give them room to grow by removal of dominating, low-quality trees and the loss of volume will be repaid manyfold.

Management of virgin stands may be summarized in a few words: Build up the younger age classes so that whenever an old tree goes out its place will be promptly taken by several blackjacks, poles, or saplings which have been waiting for liberation. If replacement is made by young trees of good form the death of old, low-value trees is really a benefit. It would pay to go into virgin stands and poison low class trees of all ages wherever doing so would make room for better ones. Even pruning may be considered in times of unemployment if the pruned trees are selected in locations where they will not be destroyed by logging.